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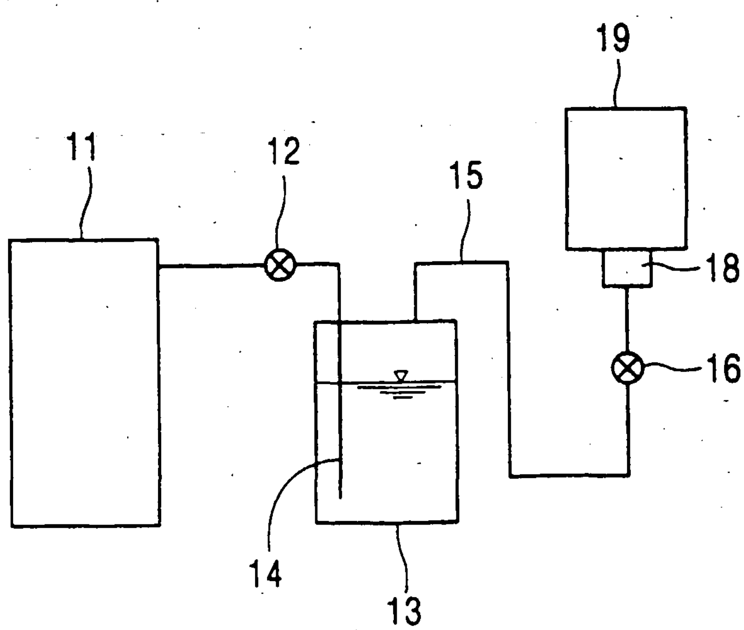
(54) Title: THE BROWN GAS COMBUSTION APPARATUS AND HEATING SYSTEM USING THE SAME



(57) Abstract: A brown gas combustion apparatus and heating system using the same is provided in which a brown gas generated from a brown gas generator flows into a water-tight flame arrester filled with hexane(C_6H_{14}) of hydrocarbon systems so as to mix the brown gas with a small amount of hexane gas, to thereby delay the combustion speed and fundamentally prevent flash-back or back-fire. The brown gas combustion apparatus includes a heating unit which is directly heated by a burner and radiates heat. The heating system includes the combustion apparatus installed upright therein, and is configured in that the high temperature water molecules scattered from the combustion apparatus absorb the infrared ray radiated from an infrared ray radiation member within the combustion chamber, and oscillate in an ultra high temperature by self-heating. Thus-obtained high temperature heat is employed for heat exchange in a water pipe arranged in a boiler, and the hot water stored in a thermal storage tank is fed for heating or hot water supply. With such a combustion apparatus employed as a heat source for brown gas boilers, heaters, furnaces and hot blast heater, pollution-free clean energy can be obtained while preventing environmental contamination.

WO 02/27247 A1

THE BROWN GAS COMBUSTION APPARATUS AND HEATING SYSTEM USING THE SAME

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a combustion apparatus utilizing charact eristics of brown gas and a heating system using such a combustion apparatus, and more particularly, to a combustion apparatus and a heating system in which brown gas is used as a clean fuel instead of a conventional fossil fuel.

Description of the Related Art

Brown gas, as referred throughout the specification, is a mixture gas in which hydrogen and oxygen produced by a water electrolysis as expressed in t he following chemical formula 1, are mixed at a mixture ratio of 2:1, like H_2 a nd O. Since brown gas with chemical equivalent ratio of 2:1 of hydrogen and oxygen, satisfies the perfect combustion condition, as expressed in the following chemical formula 2, the necessity of an additional air supply device and a chi mney or flue adopted in a conventional combustion system is eliminated.

$$\underset{\text{Water}}{\boxed{2H_2O}} \xrightarrow{\text{electrolysis}} \underset{\text{Brown Gas}}{\boxed{2H_2 + O_2}} \text{ ------ chemical formula 1}$$

$$\underset{\text{Brown Gas}}{\boxed{2H_2 + O_2}} \xrightarrow{\triangle} \underset{\text{Water}}{\boxed{2H_2O}} \text{ ----- chemical formula } 2$$

A typical combustion chamber for burning fossil fuel requires a large volume of air for combustion, and the exhaust gas(CO_2) produced from the combustion as expressed in the following chemical formulas 3, 4 and 5 has to be discharged through a chimney. In general, approximately 60% or more of the total energy supply is lost without being utilized during the combustion process.

$$\underset{\text{Acetylene}}{\boxed{2C_2H_2}} + 5O_2 \xrightarrow{\triangle} 4CO_2 + 2H_2O \text{ ----- chemical formula } 3$$

$$\underset{\text{Propane}}{\boxed{C_3H_8}} + 5O_2 \xrightarrow{\triangle} 3CO_2 + 4H_2O \text{ ----- chemical formula } 4$$

$$\underset{\text{Butane}}{\boxed{2C_4H_{10}}} + 13O_2 \xrightarrow{\triangle} 8CO_2 + 10H_2O \text{ ----- chemical formula } 5$$

There has been no remarkable progress for water electrolysis since Faraday's theory on water electrolysis published in 1833. That is to say, no one has made success in developing the gas obtained from the water electrolysis into a commercially available fuel for use in a boiler, heater or heating furnace.

The major reason for this situation is that, while it has been well known in the art that electrolysis is an attractive process for the production of hydrogen gas from water, the implosion characteristic or thermonuclear reaction characteristic which is

unique to brown gas has been ignored.

In addition, development on electrolytic cells, the core of electrolysis technology, is not so satisfactory since it has a problem in that water leaks from a torch tip when an electrolytic cell is continuously operated. Thus, it is not desirable to use a gas obtained from water electrolysis as fuel.

Brown gas has advantages in that a high energy efficiency can be obtained since brown gas used as a fuel for heating system eliminates the necessity of an air ventilation. Furthermore, comfort environment with proper humidity can be achieved since brown gas is reduced to a vapor state after combustion.

However, conventional art has failed in searching a suitable method for burning brown gas which has been considered as having extremely low heat efficiency, thus preventing brown gas from being utilized as a fuel.

The reason for this situation is that brown gas bears a high likelihood of bringing about flash-back or back-fire phenomenon since it has significantly high combustion speed. Such a phenomenon can be prevented by a water-tight flame arrester, however, since the flame of a burner goes out for every occurrences of flash-back or back-fire, there has been a need for fundamental resolution for such phenomenon.

In addition, it is difficult to obtain a sufficient amount of heat when the hydrogen gas obtained from water through electrolysis is burnt with air in a conventional method and system.

Brown gas has a combustion characteristic which can be explained as follows.

(1) completely pollution-free characteristic: brown gas does not cause any pollutant material since it is produced from water and reduced to a vapor state after combustion.

(2) complete combustion characteristic: brown gas itself contains the proper amount of oxygen required for a complete combustion since it is a mixture gas of hydrogen and oxygen with a mixture ratio of 2:1.

(3) implosion characteristic: this is a combustion characteristic of brown gas, and will be explained with reference to Fig. 1, as follows. A brown gas generator(BGG) may produce approximately 1,860ℓ of brown gas from 1ℓ of water, as expressed in the following chemical formula 6. On the contrary, as indicated by the curved line "a" in Fig. 1, when 1,860ℓ of brown gas is burnt by a spark in a sealed pressure container, a pressure drop occurs as soon as it reaches the explosion duration time(Δ T), i. e., maximum pressure 0.5MPa during 44 micro seconds(μs) (wherein, MPa is a pressure unit), and a low pressure implosion occurs at the moment of the above-described pressure drop, thus forming vacuum state with volume reduction to 1/1,860. In other words, 1ℓ of water is produced and the remaining volume becomes vacuum state, as shown in the following chemical formula 7. This can be referred to as an "implosion" expressed in chemical formula 9, which is totally different from an "explosion", expressed in chemical formula 8 and shown in the curved line "b" of Fig. 1 which indicates a pressure change caused by an explosion of common gas in a pressure container, as shown in Fig. 1

$$\underset{}{\overset{\text{Water}}{\boxed{1\ell}}} \longrightarrow \boxed{\textbf{BGG}} \longrightarrow \overset{\text{Brown Gas}}{\boxed{\textbf{1860}\ell}} \text{ ---- chemical formula 6}$$

$$\overset{\text{Brown Gas}}{\boxed{\textbf{1860}\ell}} \longrightarrow \overset{\triangle}{\boxed{\textbf{Implosion}}} \longrightarrow \overset{\text{Vacuum } \textbf{1859}\ell}{\boxed{\textbf{Water 1}\ell}} \text{ ----- chemical formula 7}$$

Hydrogen Gas, Explosion, Water

$$\boxed{2H_2} + O_2 \xrightarrow{\triangle} \boxed{2H_2O} \quad \text{----- chemical formula 8}$$

Brown Gas, Implosion, Water

$$\boxed{2H_2 + O_2} \xrightarrow{\triangle} \boxed{2H_2O} \quad \text{----------------- chemical formula 9}$$

The flame retained during the combustion of brown gas indicates the continuing process of implosion. Accordingly, the flame retained during such process generally forms a pin-point flame in which the length of flame reaches approximately 400mm.

(4) thermonuclear reaction

Brown gas is a mixture gas where the water is dissociated into hydrogen and oxygen of atomic state, rather than molecular state, and the hydrogen and oxygen are mixed at a mixture ratio of 2:1.

The flame heat retained during the combustion of brown gas has unique characteristics in that a reaction occurs between hydrogen and oxygen at either atomic state or molecular state. The hydrogen and oxygen at atomic state penetrate into atomic nucleus of the material to be heated. As a consequence, the material which is heated through a thermonuclear reaction by hydrogen and oxygen, can be applied with a flame heat of further higher temperature than that retained during the single combustion of hydrogen gas. For example, brown gas smoothly melts aluminum at a temperature of 700 °C, and even in case of tungsten, brown gas vaporizes the objective material with a heat having a temperature of 6,000 °C. Since brown gas has different thermonuclear reaction characteristics for each of the materials to be heated, it can even melt and weld blocks and iron.

Fig. 2 illustrates infrared absorption rate of water, in which the rate peaks at 3 µ m of mid-infrared radiation bandpass, and is relatively high at 6µ m to 11µ m of far-infrared radiation bandpass.

That is to say, water molecules nearly perfectly absorb infrared rays when water molecules collide against infrared rays of bandpass of 3µ m. Here, water molecules are excited so as to thereby promote collision of molecules and radiate a large volume of energy as heat.

As shown in Fig. 3, the combustion apparatus that utilizes circulating combustion of brown gas, is constructed to produce a large volume of energy by repeating a cycle in that high temperature water molecules are amplified to an ultra high temperature water molecules, ionized into H and O, and recombined, in cooperation with a self-heating phenomenon occurring when the high temperature water molecules continuously generated from a combustion process of hydrogen and oxygen of atomic state in a semi-closed combustion chamber(2) to which combustion characteristics unique to brown gas is applied, absorb infrared rays.

SUMMARY OF THE INVENTION

Therefore, it is an object of the present invention to provide a brown gas combustion apparatus in which brown gas is burnt in a semi-sealed combustion chamber adopting the characteristics of brown gas, to thereby reduce energy costs without causing occurrence of environmental pollution.

It is another object of the present invention to provide an improved heating system which prevents environmental deterioration and waste of resource utilizing the brown gas combustion apparatus.

To accomplish the above objects of the present invention, the brown gas

combustion apparatus is characterized in that a semi-sealed circulating combustion chamber without an air inlet port and a chimney, is arranged such that the interior of the circulating combustion chamber is formed of a material radiating large amount of infrared rays, and a heating unit which is directly heated by the flame of the combustion of brown gas is installed upright. The heating unit glows with a red heat, and can be heated up to 1,200 °C or higher in its entirety due to the combustion characteristics of brown gas. The vapor produced from the combustion of brown gas becomes high temperature water molecules, passing through the interior of the red-heated heating unit.

The process is repeated in which the red-heated heating unit radiates infrared rays, and high temperature water molecules raise its temperature to have an ultra high level by absorbing infrared rays when passing through the heating unit, ionized into H and O, and recombined, thus generating a large amount of heat radiating into the circulating combustion chamber.

BRIEF DESCRIPTION OF THE DRAWINGS

Additional features and advantages of the present invention will be made apparent from the following detailed description of a preferred embodiment, which proceeds with reference to the accompanying drawings, in which:

Fig. 1 is a graphical representation illustrating implosion characteristics of brown gas combustion;

Fig. 2 is a graphical representation illustrating an infrared ray absorption rate of water molecules;

Fig. 3 is a schematic view illustrating the combustion characteristics of brown gas in a sealed combustion chamber;

Fig. 4 is a schematic view illustrating the configuration of the combustion apparatus according to an embodiment of the present invention;

Fig. 5a and Fig. 5b are exploded perspective view and cross-sectional view illustrating the heating unit of a combustion apparatus according to another embodiment of the present invention;

Fig. 6a and Fig. 6b are exploded perspective view and cross-sectional view illustrating the heating unit of a combustion apparatus according to still another embodiment of the present invention;

Fig. 6c is a cross-sectional view, taken along the line A-A of Fig. 6b;

Fig. 7 is a cross-sectional view illustrating a heating system according to an embodiment of the present invention;

Fig. 8 is a fragmental cross-sectional view illustrating a peephole pipe of the heating system according to the embodiment of the present invention; and

Fig. 9 is a perspective view illustrating a spiral water pipe of the heating system according to the embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention will be explained in more detail with reference to the attached drawings. Throughout the specification, identical elements bear reference numerals, and repeated description thereof will be omitted.

Referring to Fig. 4, the brown gas combustion apparatus according to an embodiment of the present invention which aims to resolve the aforementioned problems, includes a water-tight flame arrester 13 which is communicated to a brown gas generator 11 through a gas immersion tube 14 provided with an open/shut-off valve 12 and allows a small amount of hexane(C_6H_{14}) at a vapor state to be mixed with

the brown gas produced from the brown gas generator 11; a burner 18 communicated to the water-tight flame arrester through a gas supply tube 15 provided with an open/shut-off valve 16 and which burns the brown gas passed through the water-tight flame arrester; and a heating unit 19 to be heated by the flame of the burner.

The brown gas generated from the brown gas generator 11 flows into the water-tight flame arrester 13 through the gas immersion tube 14 by the operation of the open/shut-off valve 12. The brown gas then passes through a hexane liquid which is employed as an anti-backfire liquid, and is supplied to and burnt in the burner 18 by the operation of the open/shut-off valve 16 installed at the gas supply tube 15, to thereby heat the brown gas heating unit 19.

The brown gas generated from the brown gas generator 11 flows into the water-tight flame arrester 13 filled with hexane(C_6H_{14}) of hydrocarbon systems so as to mix the brown gas with a small amount of hexane gas, to thereby delay the combustion speed. This fundamentally prevents flash-back or back-fire.

The principle of the water-tight flame arrester is that the retrogressing flame is prevented from passing the hexane liquid. In a conventional system for burning the existing gas such as an LPG or LNG, a large volume of instantaneous pressure generated from an explosion applies an impact to an anti-backfire liquid to cause the liquid to flow backward, making it impossible to adopt the water-tight back-fire system. Differently from the above-described conventional system, the combustion of brown gas causes an instantaneous vacuum state due to an implosion characteristic, exerting little influence on the flow of the brown gas and the anti-backfire liquid.

In addition, the hexane burnt during the combustion of brown gas serves to supplement heat, to thereby improve heat efficiency. However, since the oxygen constituting brown gas can be consumed by self-combustion, a portion of the brown

gas burner may not burn due to the lack of oxygen for burning the hexane mixed at a vapor state. To resolve this problem, the present invention allows the heating unit to be installed vertically upright, such that the air can be smoothly introduced from the lower portion and flow toward the upper portion of the heating unit, thus allowing the hexane to be completely burnt.

As shown in Figs. 5a and 5b, the heating unit 19 of the brown gas combustion apparatus according to another embodiment of the present invention, includes a hollow cylindrical second heating element 22 having at an outer periphery thereof a plurality of radiating holes 22a and which is mounted onto a base board 29; a fiber-reinforce metal(FRM) 23 surrounding the outer periphery of the second heating element 22; a first heating element 21 installed within the second heating element in such a manner that the first heating element is spaced apart from the bottom surface of the second heating element through a reciprocal cone-shaped heating portion 21a arranged at the lower end of the first heating element; and a cap 24 arranged at the top of the first and second heating elements 21 and 22.

The burner is installed at a burner hole 28a formed at the central portion of the base board, and is provided with an ignition device 28c.

The second heating element is firmly connected to the base board 29 via a supporting member 29a.

Thus-configured combustion apparatus is characterized in that the heating portion 21a arranged at the lower end of the first heating element is directly heated by a flame 28b of brown gas containing a small amount of hexane at a vapor state, and the upper portion of the first heating element as well as the heating portion 21a glows with a red heat by the thermonuclear reaction characteristic of brown gas, thus radiating a high temperature heat.

Here, since the heat release is cut off by the cap 24 arranged on the top portions of the first and second heating elements, the heat radiated from the first heating element 21 serves to heat the second heating element. At the same time, the high temperature vapor produced from the combustion of brown gas passes through the fiber-reinforced metal 23 that surrounds the outer periphery of the second heating element 22, via the radiating holes 22a formed at a regular spacing at the second heating element, and scatters outwardly from the heating unit 19. With such a process, the fiber-reinforced metal 23 consequently glows with a red heat. As a result, the heating unit 19 of the brown combustion apparatus of the present invention in its entirety glows with a red heat, releasing a huge amount of heat.

This can be explained in more detail as follows. Since the flame of the brown gas itself retains implosion and the heat is focused into a single point smoothly forming a pin-point flame, the flame does not diffuse causing little amount of lateral heat.

Thus, thermonuclear reaction is induced by allowing the heating element to be directly heated by the flame of brown gas, thereby producing a large volume of heat. As a material constituting the heating unit, nickel-chrome alloy, aluminum-chrome alloy or alumina ceramics which has a heat resistance against the temperature of 1300 °C or higher, is employed.

As shown in Figs. 6a, 6b and 6c, the heating unit 19 of a brown gas combustion apparatus according to still another embodiment of the present invention, includes a hollow and cylindrical second heating element 35 having at an outer periphery thereof a plurality of upper holes 36a and 36b and a lower hole 36c and which is mounted onto the base board 29; and a first heating element 31 having a rectangular insertion portion 33 and a circular protrusion 32 protruded outwardly from

an upper outer periphery of the insertion portion 33, the rectangular insertion portion 33 and the circular protrusion 32 being formed integrally, the first heating element 31 having a plurality of side flame guide grooves 34b formed from the insertion portion 33 toward the lateral surface of the lower portion of the circular protrusion 33 and a central flame guide hole 34a perforated in vertical direction, the circular protrusion 32 being mounted onto the second heating element 35 with a predetermined spacing from the bottom surface of the second heating element 35.

When the brown gas supplied to the burner 18 is ignited by the ignition device 28c, the flame 28a is formed as being elongated. The flame 28a heating the first heating element 31 proceeds upwardly along the central flame guide hole 34a and the lateral flame guide groove 34b. The first heating element 31 is heated in such a manner that the lower end of the first heating element 31 glows with a red heat first, and subsequently the second heating element 35 glows with a red heat, thus allowing the heating unit 19 to be heated in its entirety up to 1,200 °C or higher. Here, the vapor passing through the central flame guide hole 34a and the lateral flame guide groove 34b turns into high temperature water molecules which in turn absorb infrared rays and is raised to have an ultra high temperature so as to be scattered.

The upper holes 36a and 36b of the second heating element 35 eject flame while the lower hole 36c takes air.

As a material constituting the heating unit, the compressed and molded high ceramics with alumina constituent contained therein can be used.

Referring now to Fig. 7, a heating system according to an embodiment of the present invention includes the brown gas generator 11, the heating unit 19, a circulation combustion chamber 40, and a boiler body 50. The brown gas generated from the brown gas generator 11 flows into the water-tight flame arrester 13 along the

gas supply tube 15 and is mixed with a hexane gas at a predetermined mixture ratio. Then, the mixture gas is transported to the gas burner 18. The gas supply tube 15 is provided with the gas supply control valve 16 installed thereto so as to control the amount of gas, and a solenoid valve 17 so as to automatically supply or cut off gas. The heating system is automatically ignited or turned off by the ignition device 28.

The heating system includes the water-tight flame arrester 13 which is communicated to the brown gas generator 11 through the gas immersion tube 14 provided with the open/shut-off valve 12 and allows a small amount of hexane(C_6H_{14}) at a vapor state to be mixed with the brown gas produced from the brown gas generator 11; the burner 18 communicated to the water-tight flame arrester through the gas supply tube 15 provided with the open/shut-off valve 16 and which burns the brown gas passed through the water-tight flame arrester; the heating unit 19 to be heated by the flame of the burner; the circulating combustion chamber 40 formed of a far infrared radiation member 41 surrounding the heating unit 19 with a predetermined space interposed therebetween; a water tube 51 spirally surrounding the outer periphery of the circulating combustion chamber 40; a thermal storage tank 52 surrounding the outer periphery of the water tube 51 with an air flow passage 42 interposed therebetween, and which has an upper portion communicated to an exhaust pipe 46; and an adiabatic member 53 surrounding the thermal storage tank 52.

The heating unit 19 is constituted by the first heating elements 21 and 31 and the second heating elements 22 and 35 discussed with reference to Figs. 5a, 5b, 6a and 6b.

Fig. 8 is a detailed cross-sectional view illustrating a peephole pipe 43 communicated to the upper portion of the circulating combustion chamber 40 of the heating system of the present invention. The peephole pipe 43 communicating the

upper portion of the circulating combustion chamber 40 and penetrating through the far infrared radiation member 41 and the thermal storage tank 52 is installed on the boiler body 50. The peephole pipe 43 can be used as an exhaust pipe which prevents the interior of the circulating combustion chamber 40 and the interior of the air flow passage 42 from dewing in the early stage of operation of the heating system. The cap 44 arranged at an end of the exhaust pipe is made up of a heat resisting glass 45, thus allowing the peephole pipe to function as an inspection device for monitoring the interior of the circulating combustion chamber 40.

The boiler body 50 for producing hot water is mounted onto the hollow base board 29, and is provided with the water tube 51 installed therein in such a manner as to have a large area of heat transfer surface for absorbing heat. The water tube 51 is arranged outside the far infrared radiation member 41, and the thermal storage tank 52 surrounding the far infrared radiation member 41 is heat-insulated by the adiabatic member 53 so as to thereby store hot water.

In such a configuration, a space is naturally formed between the thermal storage tank 52 and the far infrared radiation member 41. Thus-formed space serves as the air flow passage 42 which supplies heat to the inner surface of the water tube 51 and the thermal storage tank 52 by a smooth circulation of the high temperature air current formed within the circulating combustion chamber 40.

Since the far infrared radiation member 41 radiates far infrared rays toward the inside, i.e., toward the circulating combustion chamber 40, and also toward the outside, i.e., toward the air flow passage 42, the water tube 51 exchanges heat by the movement of the air current formed within the circulating combustion chamber 40 and is heated by the far infrared rays, thus achieving a double effectiveness of heating.

The air current formed within the circulating combustion chamber 40 passes

through the air flow passage 42 and flows upwardly so as to thereby heat the water tube. Subsequently, the air current with lowered temperature is gradually discharged through the exhaust pipe 46.

Fig. 9 is a perspective view illustrating the water tube 51 of the heating system according to the present invention. The heating system of the present invention has the highest temperature at the top portion of the far infrared radiation member 41 or the combustion chamber 40. Therefore, the water tube 51 of the heating system of the present invention is arranged to form a coil shape, and an ending portion 51a of the water tube 51 is formed in such a manner as to sufficiently cover the cylindrical upper portion thereof. This configuration attributes to a maximized heat exchange efficiency.

Although a variety of materials may be used as a material for forming the far infrared radiation member 41, it is preferable to use a thin iron sheet spray-coated with plasma, considering the volume of the far infrared radiation member and further the heating system.

In addition, the brown gas boiler of the present invention is provided with the thermal storage tank 52 in order to utilize midnight electrical power service. It is also possibile to design the boiler to have a sufficient amount of inner watering with an automatic controller for controlling the temperature of hot water to be maintained at the temperature of 40 °C to 90 °C. Such a configuration prevents the interior of the combustion chamber and the interior of the air flow passage 42 from dewing when the heating system is operated at the temperature of 40 °C or higher.

The hot water stored within the thermal storage tank 52 is supplied along a heating pipeline and a hot water pipeline, respectively. A circulation pump is installed so as to allow the hot water to be smoothly supplied along the pipeline, and the hot water is supplied to a heating coil through a three-way valve so as to perform an

indoor area heating function. In addition, the replenishment of the hot water is controlled by a controller in accordance with the sensing result from a water lever sensor of a feedwater tank installed onto the boiler body.

Such functions are the same as those of a common heating system, and the detailed description thereof will be omitted. The inlet and outlet portions of the water tube 51 is omitted too.

As described above, a brown gas combustion apparatus using brown gas obtained by water electrolysis and a heating system using brown gas combustion apparatus, searches to realize an ideal system and method for utilizing water as a fuel.

The combustion apparatus of the present invention is one of a key techniques which can be adopted to all appliances using brown gas as a fuel. With such a combustion apparatus employed as a heat source for brown gas boilers, heaters, furnaces and hot blast heater, pollution-free clean energy can be obtained while preventing environmental contamination.

While the heating system adopting the combustion apparatus of the present invention has been illustrated and described as an embodiment from among a variety of examples, it is to be understood that the combustion apparatus could be adopted to refuse incinerators so as to effectively treat the refuse without departing from the scope of the present invention.

Having described a preferred embodiment of the invention with reference to the accompanying drawings, it is to be understood that the present invention is not limited to that precise embodiment and that various changes and modifications could be effected therein by one skilled in that art without departing from the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. A brown gas combustion apparatus using brown gas as a fuel, comprising:

a water-tight flame arrester which is communicated to a brown gas generator through a gas immersion tube provided with an open/shut-off valve and allows a small amount of hexane(C_6H_{14}) at a vapor state to be mixed with a brown gas produced from said brown gas generator;

a burner communicated to said water-tight flame arrester through a gas supply tube provided with an open/shut-off valve and which burns the brown gas passed through said water-tight flame arrester; and

a heating unit to be heated by a flame of said burner.

2. A brown gas combustion apparatus according to claim 1, wherein said heating unit comprises:

a hollow cylindrical second heating element having at an outer periphery thereof a plurality of radiating holes and which is mounted onto a base board;

a fiber-reinforce metal(FRM) surrounding an outer periphery of said second heating element;

a first heating element installed within said second heating element in such a manner that said first heating element is spaced apart from a bottom surface of said second heating element through a reciprocal cone-shaped heating portion arranged at a lower end of said first heating element; and

a cap arranged at a top of said first and second heating elements.

3. A brown gas combustion apparatus according to claim 1, wherein said heating unit comprises:

a hollow and cylindrical second heating element having at an outer periphery thereof a plurality of upper holes and a lower hole and which is mounted onto said base board; and

a first heating element having a rectangular insertion portion and a circular protrusion protruded outwardly from an upper outer periphery of said insertion portion, said rectangular insertion portion and said circular protrusion being formed integrally, said first heating element having a plurality of side flame guide grooves formed from said insertion portion toward a lateral surface of a lower portion of said circular protrusion and a central flame guide hole perforated in vertical direction, said circular protrusion being mounted onto said second heating element with a predetermined spacing from a bottom surface of said second heating element.

4. A heating system using brown gas as a fuel, comprising:

a water-tight flame arrester which is communicated to a brown gas generator through a gas immersion tube provided with an open/shut-off valve and allows a small amount of hexane(C_6H_{14}) at a vapor state to be mixed with a brown gas produced from said brown gas generator;

a burner communicated to said water-tight flame arrester through a gas supply tube provided with an open/shut-off valve and which burns the brown gas passed through said water-tight flame arrester;

a heating unit to be heated by a flame of said burner;

a circulating combustion chamber formed of a far infrared radiation member surrounding said heating unit with a predetermined space interposed therebetween;

a water tube spirally surrounding an outer periphery of said circulating combustion chamber;

a thermal storage tank surrounding an outer periphery of said water tube with an air flow passage interposed therebetween, and which has an upper portion communicated to an exhaust pipe; and

an adiabatic member surr ounding said thermal storage tank.

5. A heating system according to claim 4, wherein said circulating combustion chamber has at a top portion thereof a peephole pipe communicated thereto for observing an interior of said circulating combustion chamber and preventing dewing in an early stage of operation of said heating system by opening a cap.

6. A heating system according to one of claim 4 or claim 5, wherein said heating unit comprises:

a hollow cylindrical second heating element having at an outer periphery thereof a plurality of radiating holes and which is mounted onto a base board;

a fiber-reinforce metal(FRM) surrounding an outer periphery of said second heating element;

a first heating element installed within said second heating element in such a manner that said first heating element is spaced apart from a bottom surface of said second heating element through a reciprocal cone-shaped heating portion arranged at a lower end of said first heating element; and

a cap arranged at a top of said first and second heating elements.

7. A heating system according to one of claim 4 or claim 5, wherein said heating unit comprises:

a hollow and cylindrical second heating element having at an outer periphery

thereof a plurality of upper holes and a lower hole and which is mounted onto said base board; and

a first heating element having a rectangular insertion portion and a circular protrusion protruded outwardly from an upper outer periphery of said insertion portion, said rectangular insertion portion and said circular protrusion being formed integrally, said first heating element having a plurality of side flame guide grooves formed from said insertion portion toward a lateral surface of a lower portion of said circular protrusion and a central flame guide hole perforated in vertical direction, said circular protrusion being mounted onto said second heating element with a predetermined spacing from a bottom surface of said first heating element.

Fig. 1

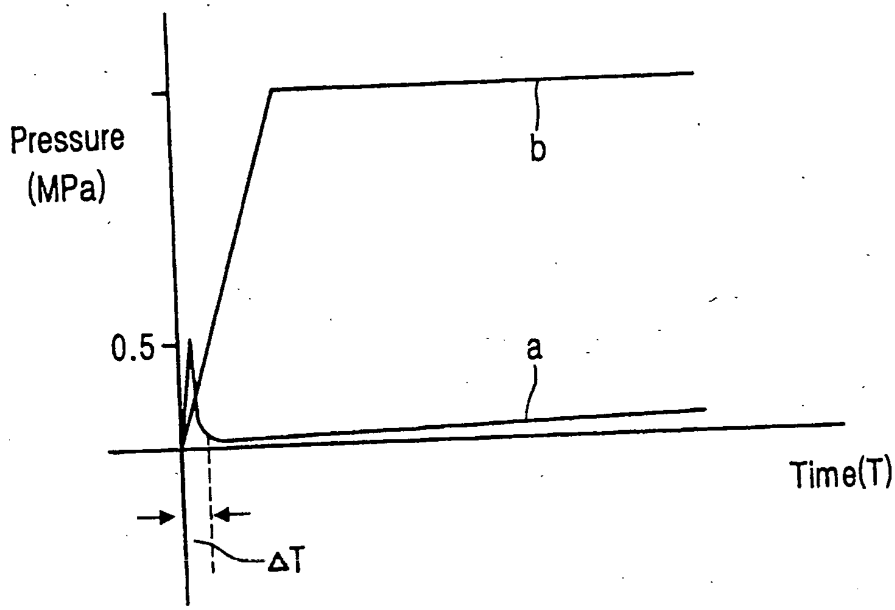

Pressure
(MPa)
0.5
b
a
Time(T)
ΔT

Fig. 2

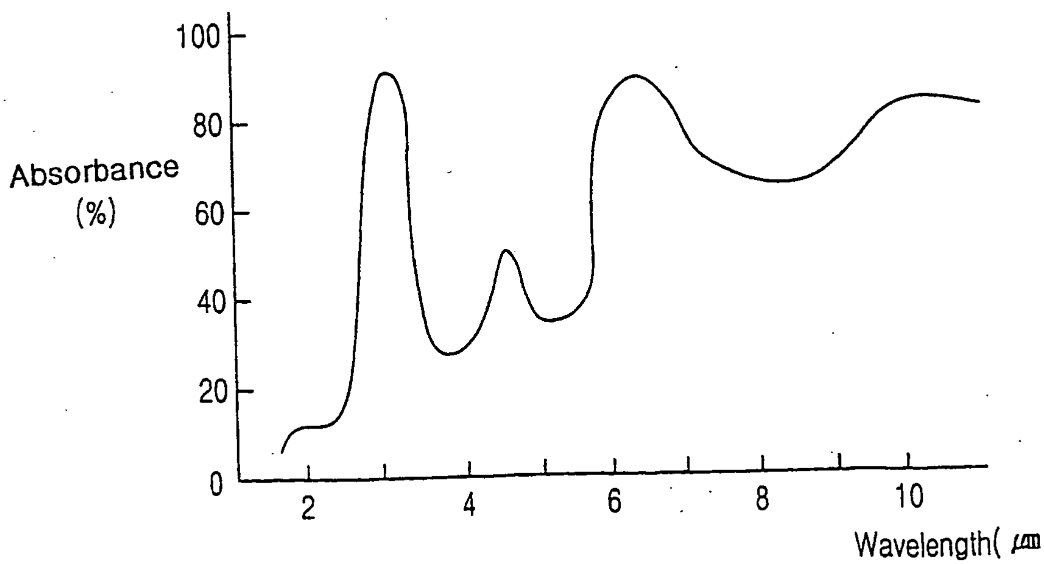

Absorbance
(%)
100
80
60
40
20
0
2
4
6
8
10
Wavelength(μm)

Fig . 3

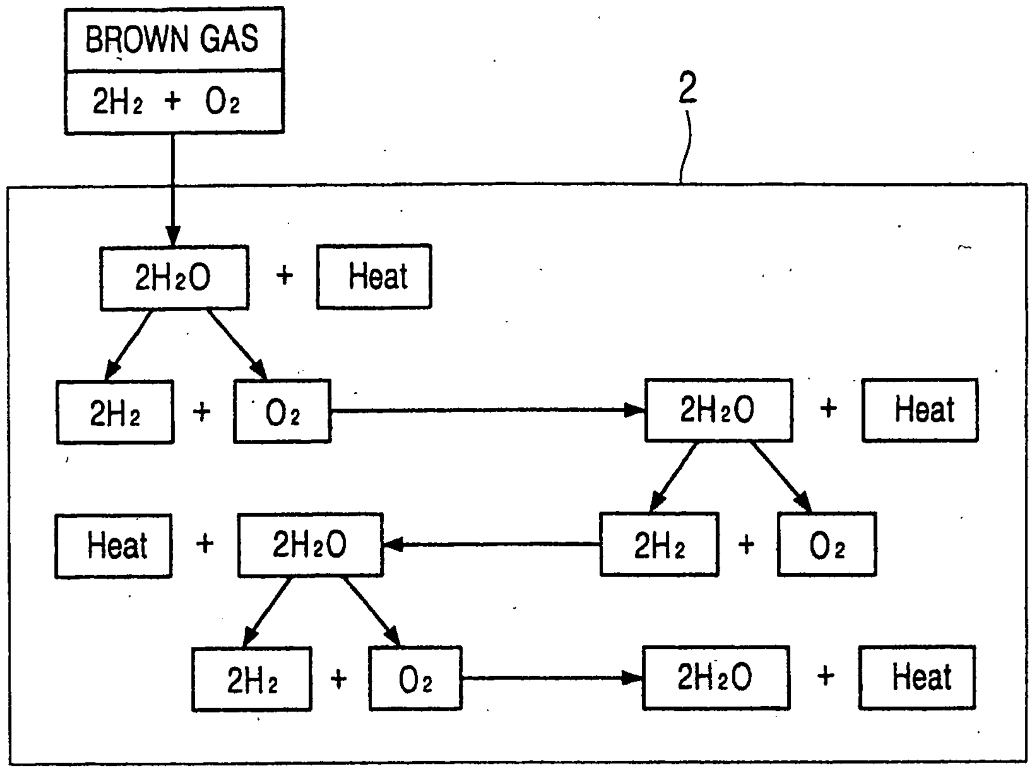


Fig. 4

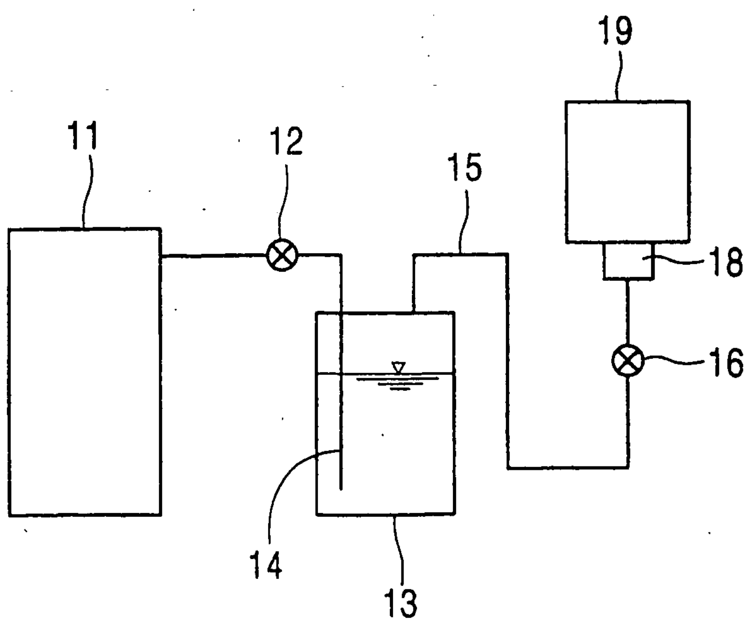


Fig. 5a

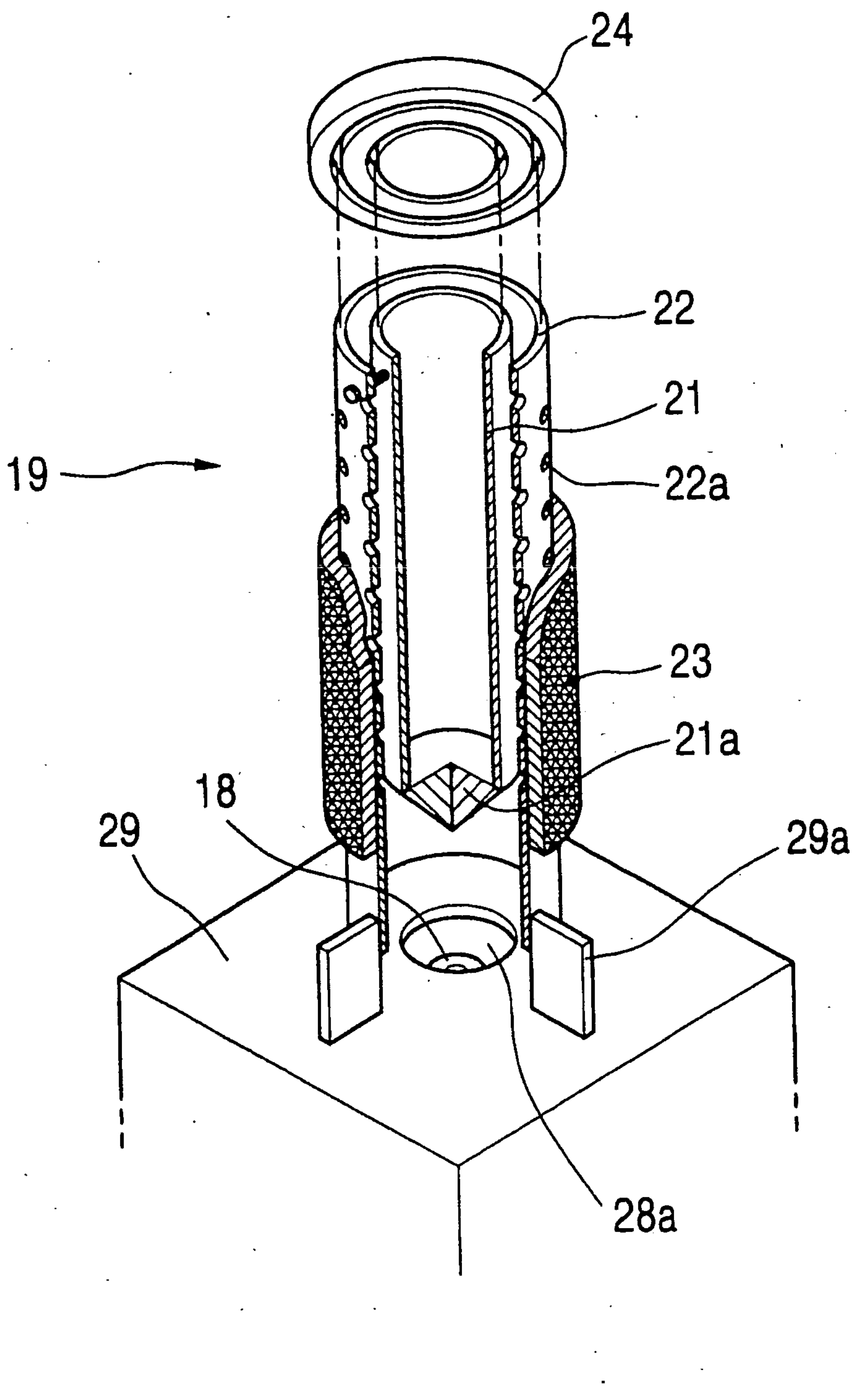


Fig. 5b

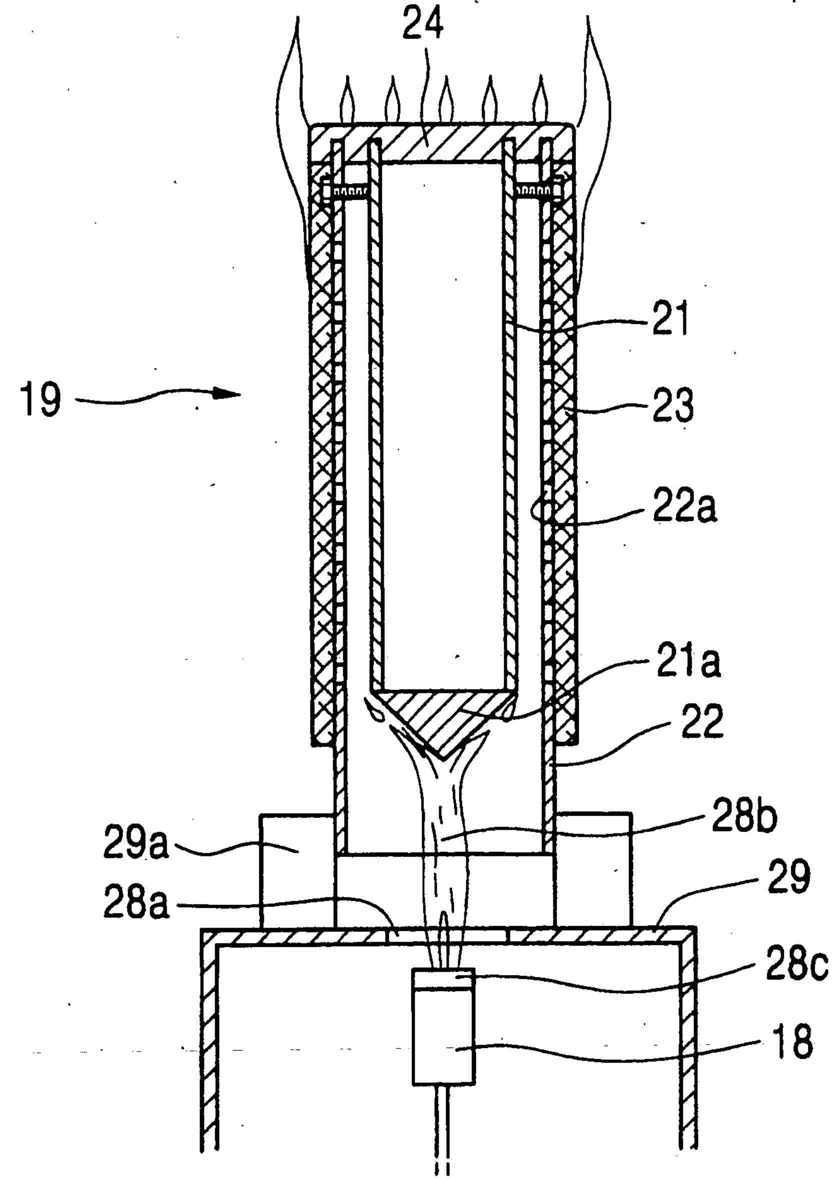


Fig. 6a

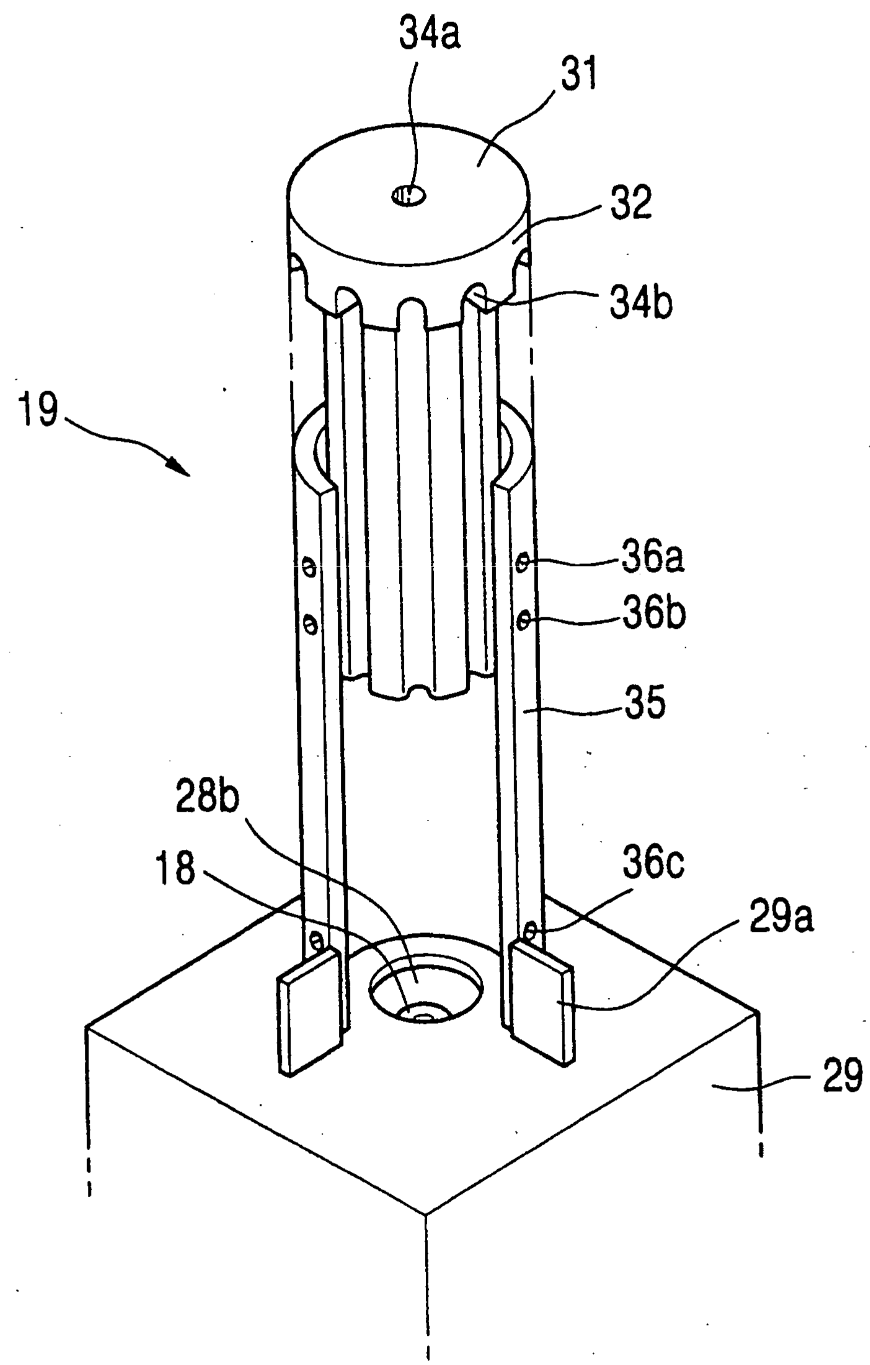


Fig. 6b

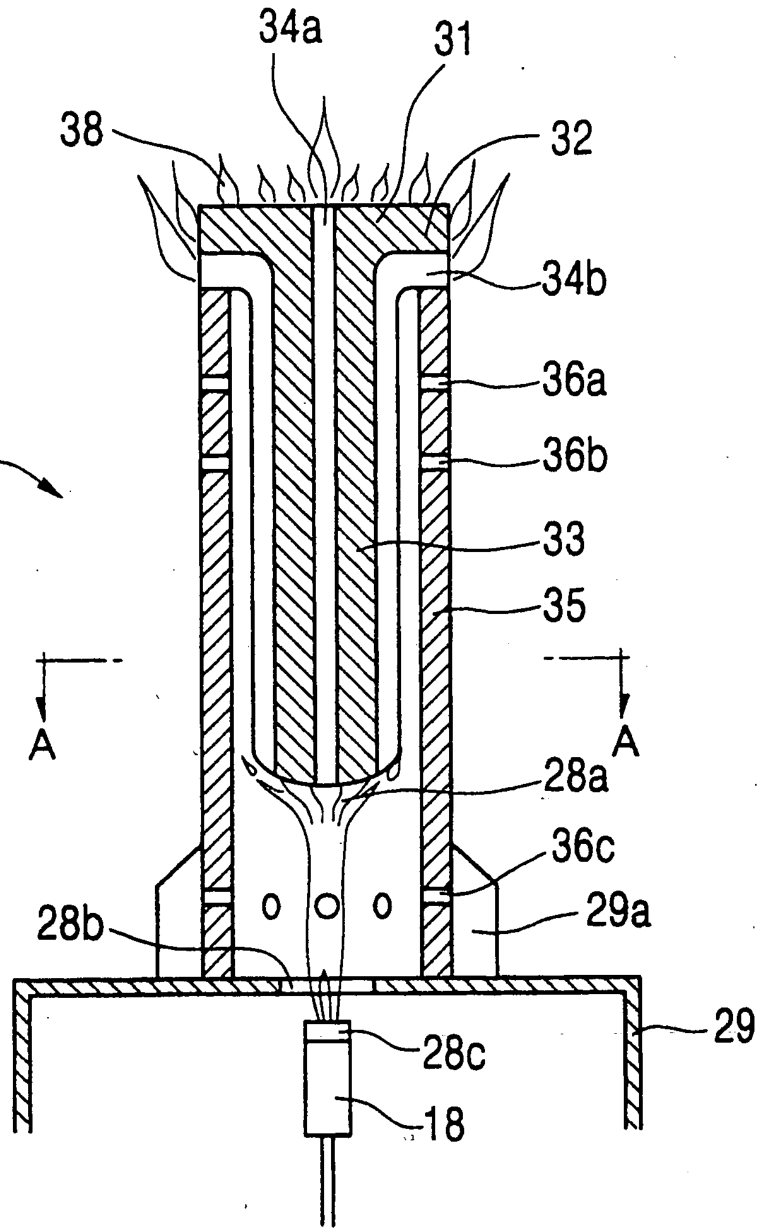


Fig. 6c

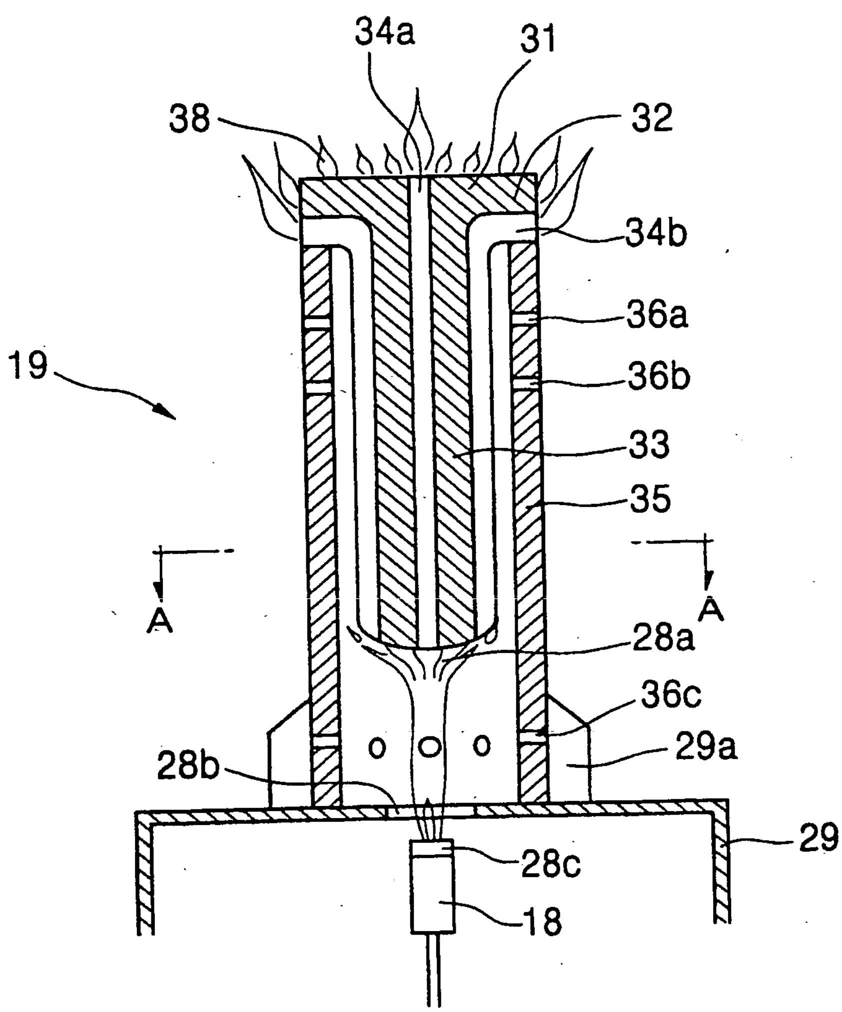

34a
31
38
32
34b
36a
36b
19
33
35
A
A
28a
36c
29a
28b
29
28c
18

Fig. 6c

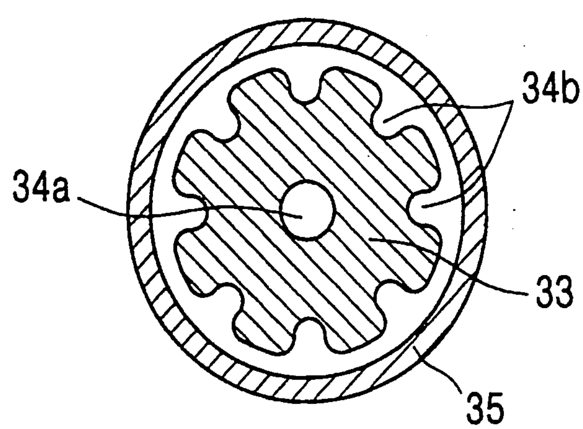

34b
34a
33
35

Fig. 7

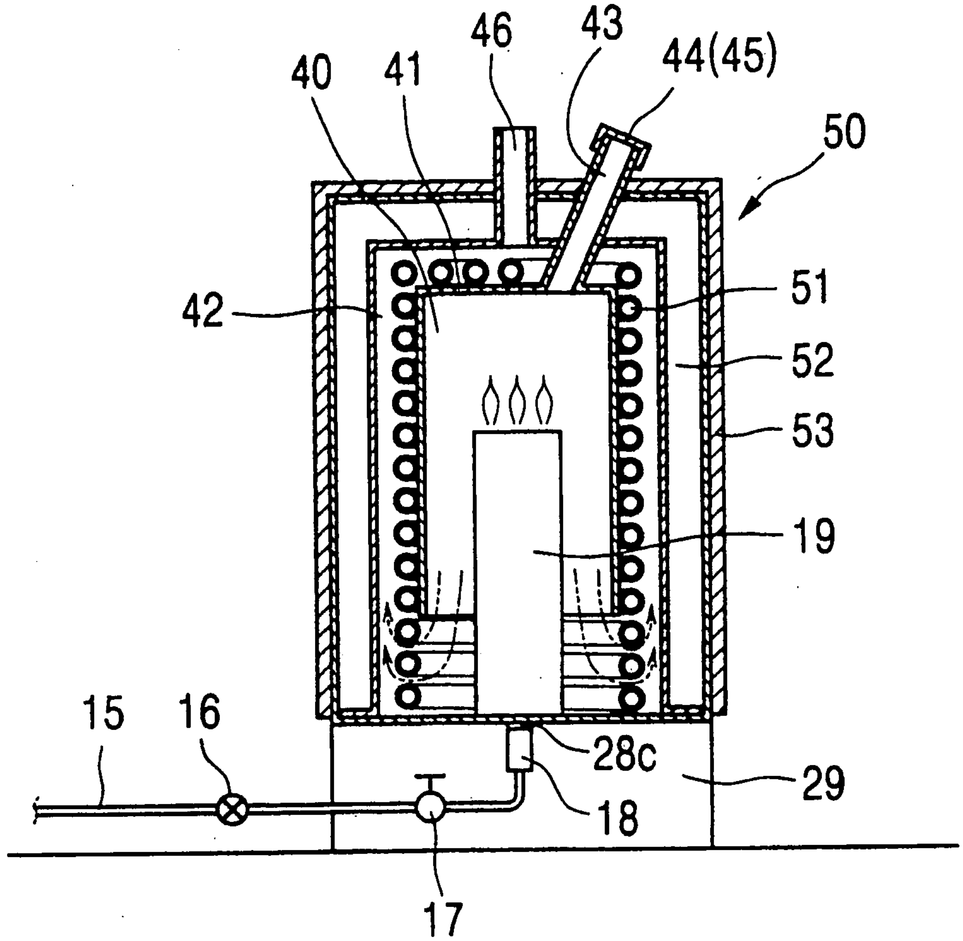


Fig. 8

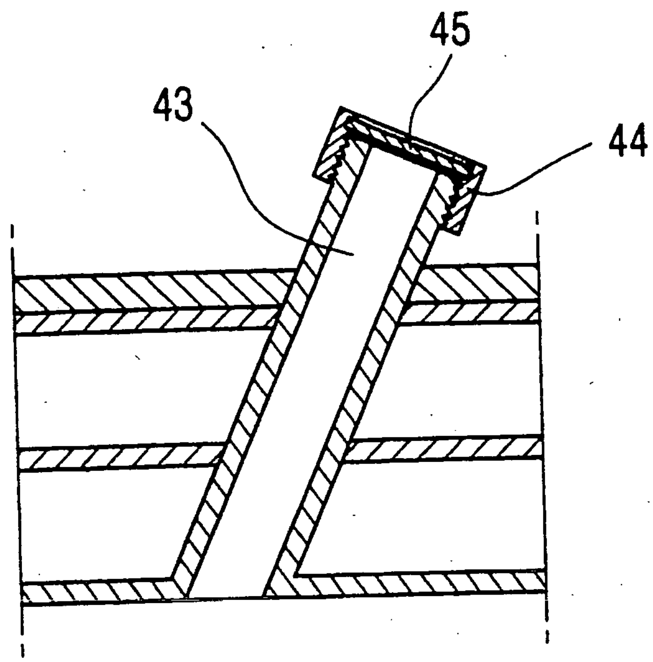
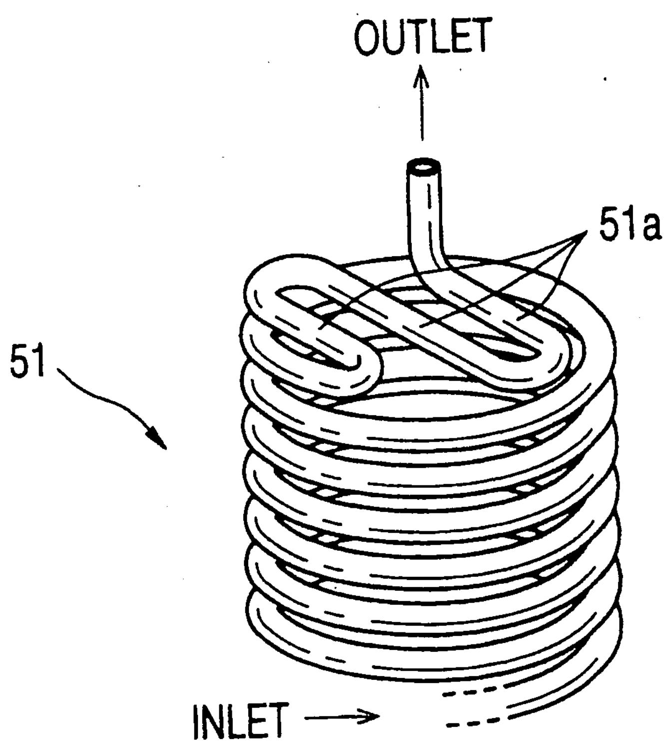


Fig. 9



INTERNATIONAL SEARCH REPORT

ternational application No.
PCT/KR01/00260

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 F24J 1/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimun documentation searched (classification system followed by classification symbols)

IPC7 F24J 1/00, F23C 11/00, F23D 14/82

Documentation searched other than minimun documentation to the extent that such documents are included in the fileds searched

Korean Patents and applications for inventions since 1975, Korean Utility models and applications for Utility models since 1975, Japanese Utility models and applications for Utility models since 1975.

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search trerms used)

NPS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2000-129480 A (KIM SANGNAM) 9 MAY 2000 see the whole document	1
Y	JP 2000-161017 A (ZENSHIN DENRYOKU ENGINEERING) 13 JUNE 2000 see the whole document	1
A	JP 11-264507 A (KIM SANGNAM) 28 SEPTEMBER 1999 see the whole document	1-7
A	KR 20-182683 Y (HYUN JANGSOO) 8 MARCH 2000 see the whole document	1-7

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

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"P" document published prior to the international filing date but later than the priority date claimed

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 JUNE 2001 (18.06.2001)	21 JUNE 2001 (21.06.2001)

Name and mailing address of the ISA/KR	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/KR01/00260

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2000-129480 A	09.05.2000	KR 2000-2681 A	15.05.2000
JP 2000-161017 A	13.06.2000	None	
JP 11-264507 A	28.09.1999	None	
KR 20-182683 Y	08.03.2000	None	